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(54) **Water-soluble surface treating agents**

(57) A surface treating agent comprising a reaction product of (A) a fluoroalkyl group-containing alkoxysilane with (B) an amino group-containing alkoxysilane and optionally further with (C) an alkyl group-containing

alkoxysilane is water soluble. The agent is diluted with water to form a solution for treating glass and other substrates to impart durable water repellency and other improved properties to the substrates.

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Description

This invention relates to water-soluble surface treating agents, their preparation and use. Use is proposed with substrates such as glass, inorganic materials, ceramics, metals, and plastics. Desired properties of the treated surface are selectable from water repellent, oil repellent, moisture-proof, stain-proof, anti-icing, lubricant, mould release, weather resistant, and durability properties.

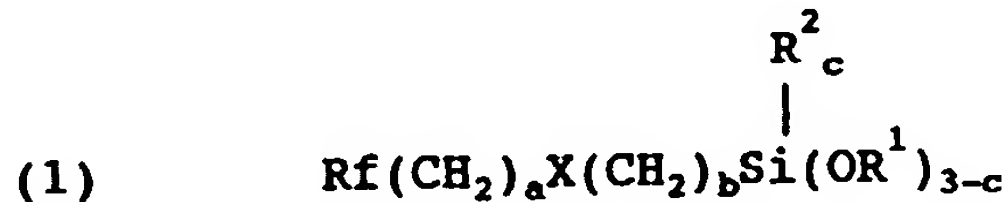
The current mainstream surface treating agents for glass to form durably water repellent coatings contain as an active ingredient fluoroalkyl group-containing silanes which are diluted with organic solvents. Agents of the solvent dilution type are full of hazards including fire, explosion, poisoning, and environmental pollution. From the aspects of protection of the global environment and utilization of resources too, there is a strong demand for an organic solvent-free surface treating agent for glass, especially a water-soluble surface treating agent for glass.

Some water-soluble surface treating agents are known in the art. For example, US-A-2,814,572 discloses a glass surface treating agent comprising a water-soluble organosilicon compound. The compound is diluted with water to form a transparent mixture. The agent must be used within one day after dilution since the mixture is poor in shelf stability due to rapid polymerization reaction. Water repellency is low since a long chain alkyl group is the only water repellent component.

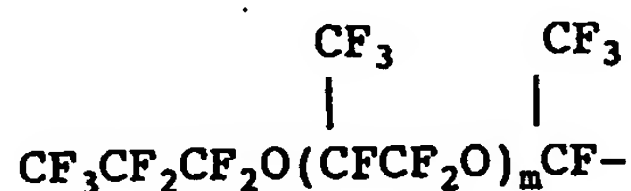
The aim herein is to provide new and useful surface treating agents, preferably with enhanced properties such as shelf stability water repellency and durability, as well as methods of preparation and use thereof.

We have found that a reaction product of (A) a fluoroalkyl group-containing alkoxysilane of the general formula (1) and/or its partial hydrolysate with (B) an amino group-containing alkoxysilane of the general formula (2) and/or its partial hydrolysate, and a reaction product of components (A) and (B) with an alkyl group-containing alkoxysilane of the general formula (3) and/or its partial hydrolysate, (formulae shown below) are effective as active ingredients for a surface treating agent. These reaction products are designed so as to impart water solubility to a fluoroalkyl group-containing silane compound which is in itself effective as a water repellent component. Since the reaction products are soluble in water, we find that such surface treating agents can be stable during shelf storage. We also find good properties such as water repellency, and formation of durable coatings.

Formula (1):



In formula (1), Rf is C_nF_{2n+1} or a polyfluoroalkyl group represented by

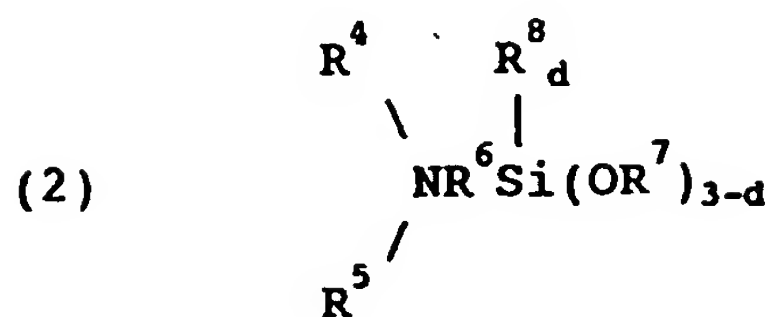


wherein n is an integer of 1 to 20 and m is an integer of at least 1, which may have at least one ether bond,

X is at least one linkage group selected from the class consisting of $-CH_2-$, $-CH_2O-$, $-NR^3-$, $-CO_2-$, $-CONR^3-$, $-S-$, $-SO_3-$, and $-SO_2NR^3-$ wherein R^3 is a hydrogen atom or alkyl group of 1 to 8 carbon atoms,

R^1 is an alkyl group having 1 to 4 carbon atoms, R^2 is an alkyl group having 1 to 4 carbon atoms, letter a is an integer of 0 to 3, b is an integer of 1 to 3, and c is equal to 0 or 1.

Formula (2):

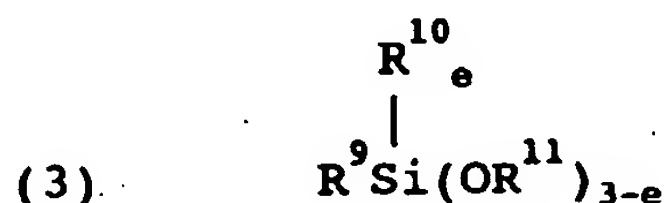


In formula (2), R^4 and R^5 are independently selected from the class consisting of a hydrogen atom, alkyl group having 1 to 15 carbon atoms, and aminoalkyl group having 1 to 15 carbon atoms,

R^6 is a divalent hydrocarbon group having 1 to 18 carbon atoms, R^7 is an alkyl group having 1 to 4 carbon atoms,

R^8 is an alkyl group having 1 to 4 carbon atoms, and letter d is equal to 0 or 1.

Formula (3):



In formula (3), R^9 is a monovalent hydrocarbon group having 1 to 10 carbon atoms,

R^{10} is an alkyl group having 1 to 4 carbon atoms,

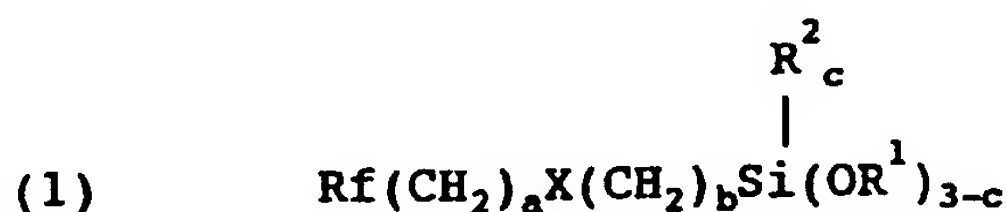
R^{11} is an alkyl group having 1 to 4 carbon atoms, and

letter e is equal to 0 or 1.

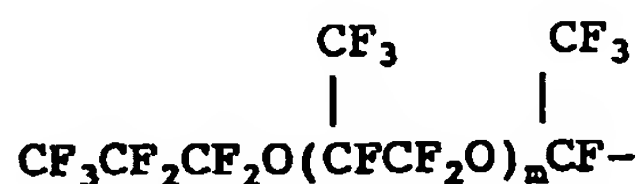
Therefore, the present invention provides a water-soluble surface treating agent comprising a reaction product of components (A) and (B) or a reaction product of components (A), (B), and (C) and water.

FURTHER EXPLANATIONS, PREFERRED AND OPTIONAL FEATURES

The water-soluble surface treating agent of the invention is described in more detail. Component (A) is a fluoroalkyl group-containing alkoxy silane of the general formula (1).



In formula (1), R_f is C_nF_{2n+1} or a polyfluoroalkyl group represented by

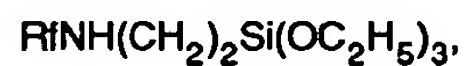
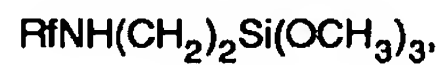
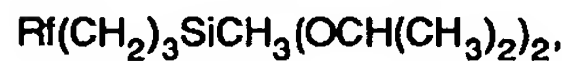
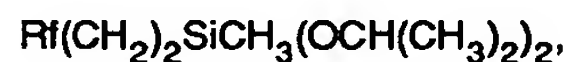


wherein n is an integer of 1 to 20, preferably 1 to 10 and m is an integer of at least 1, preferably 1 to 20, more preferably 1 to 10, which may have at least one ether bond. X is at least one linkage group selected from the class consisting of $-CH_2-$, $-CH_2O-$, $-NR^3-$, $-CO_2-$, $-CONR^3-$, $-S-$, $-SO_3-$, and $-SO_2NR^3-$ wherein R^3 is a hydrogen atom or alkyl group of 1 to 8 carbon atoms. Where X is more than one such group, they are bonded to form a divalent linkage group. R^1 is an alkyl group having 1 to 4 carbon atoms. R^2 is an alkyl group having 1 to 4 carbon atoms. Methyl and ethyl are preferred

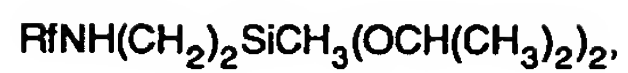
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for R¹ and R². Letter a is an integer of 0 to 3, b is an integer of 1 to 3, and c is equal to 0 or 1, preferably 0. Usually X is not more than 6 said linkage groups.

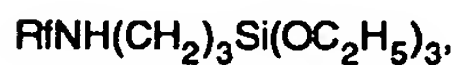
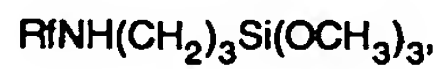
Illustrative, non-limiting, examples of the fluoroalkyl group-containing alkoxysilane are given below. In the following formulae, Rf is C_nF_{2n+1} wherein n is an integer of 1 to 20, for example, CF₃-, C₂F₅-, C₃F₇-, C₄F₉-, C₆F₁₃-, C₈F₁₇-, C₁₀F₂₁-, C₁₂F₂₅-, C₁₄F₂₉-, C₁₆F₃₃-, C₁₈F₃₇-, and C₂₀F₄₁-.



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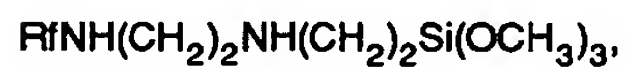
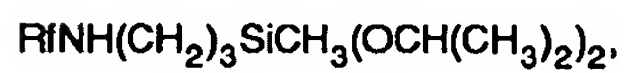
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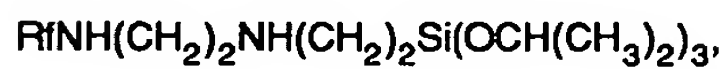
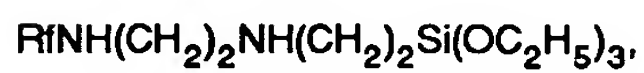
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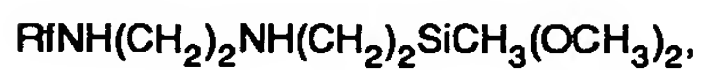
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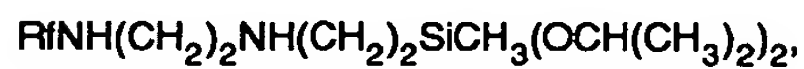
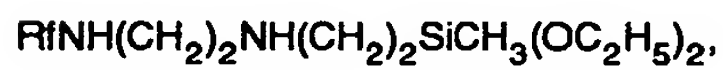
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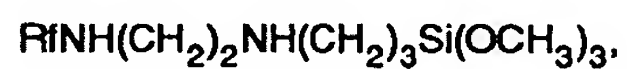
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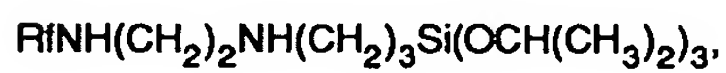
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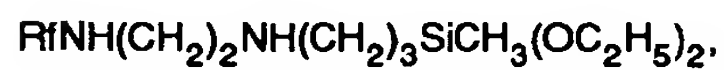
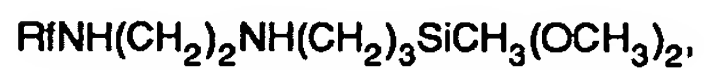
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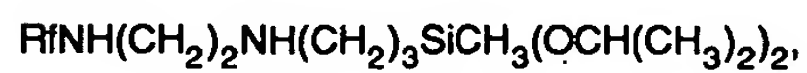
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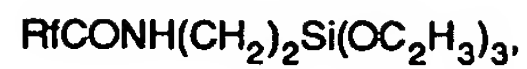
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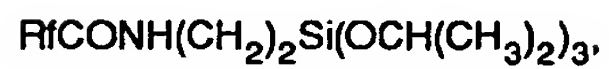
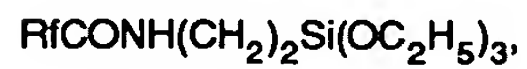
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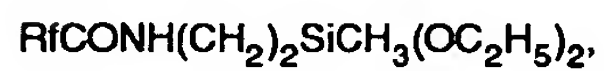
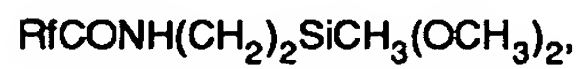
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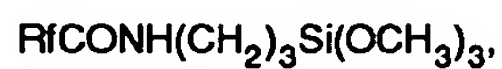
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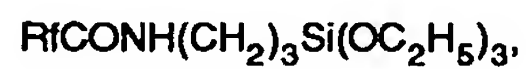
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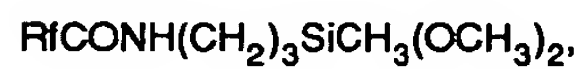
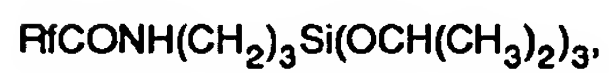
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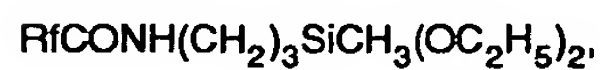
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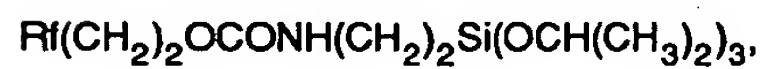
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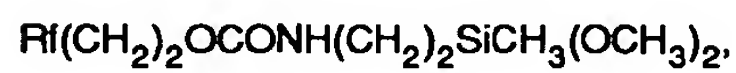
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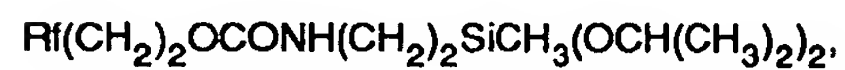
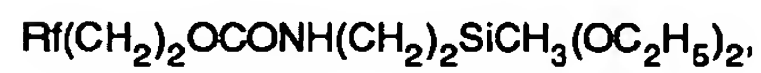
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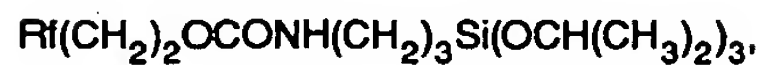
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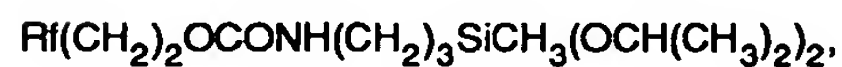
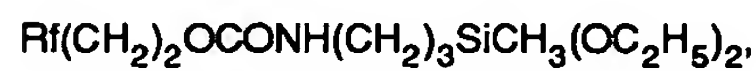
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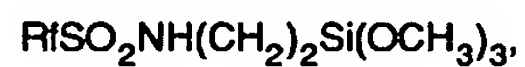
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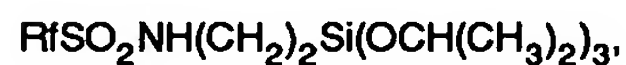
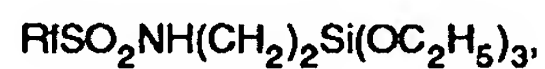
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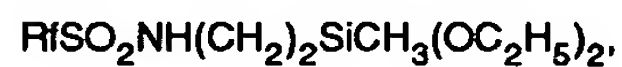
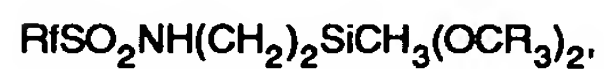
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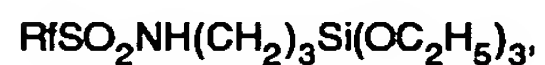
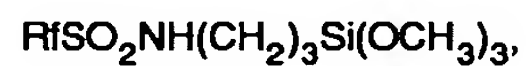
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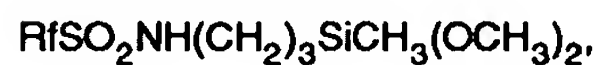
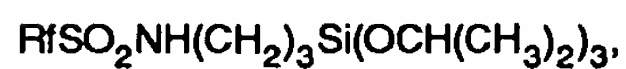
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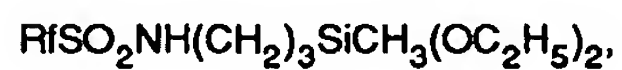
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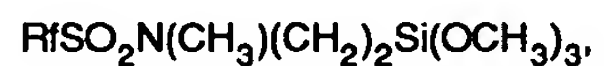
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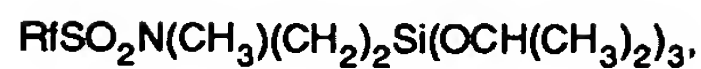
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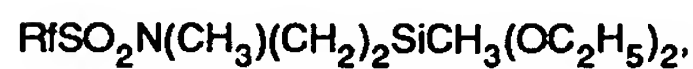
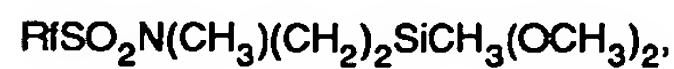
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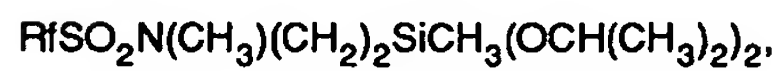
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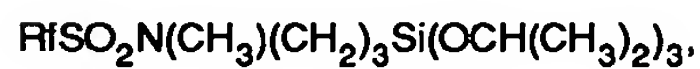
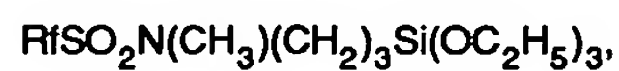
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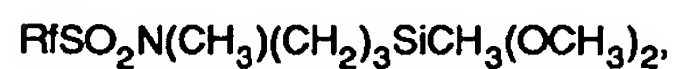
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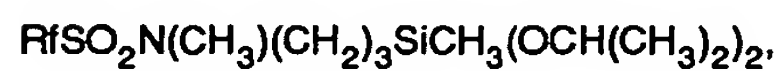
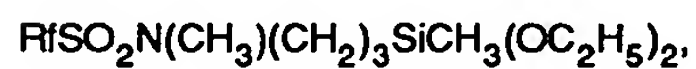
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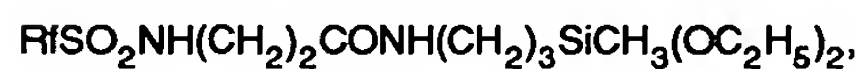
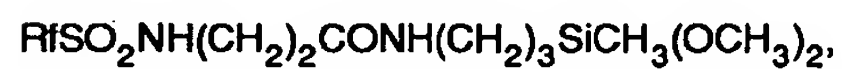
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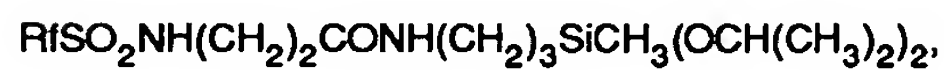
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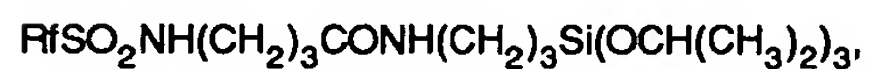
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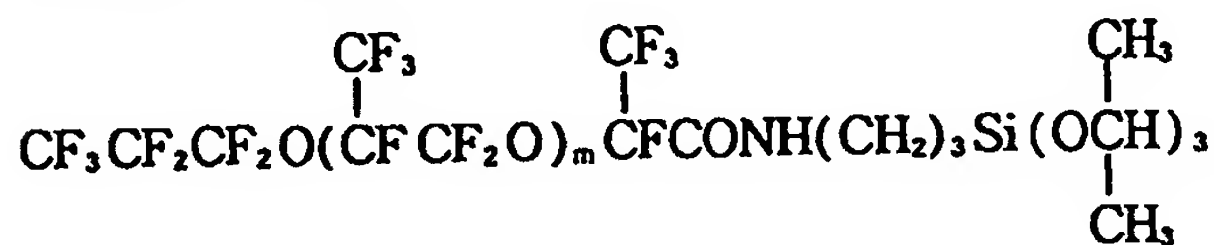
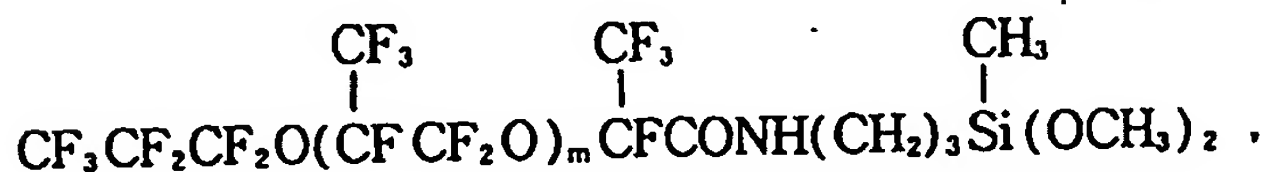
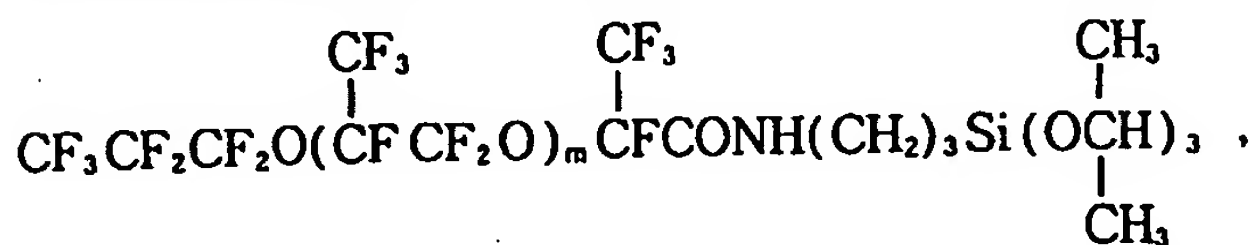
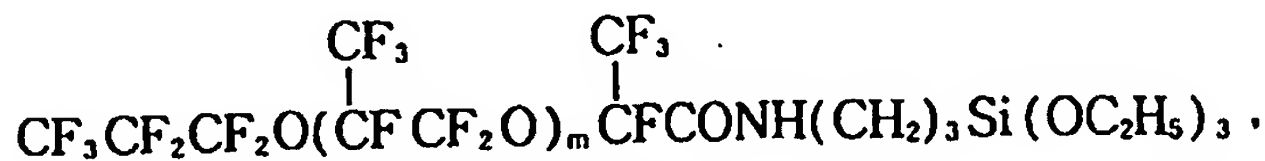


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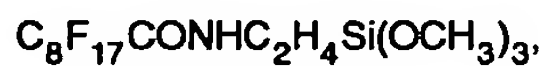
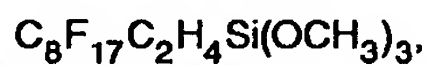




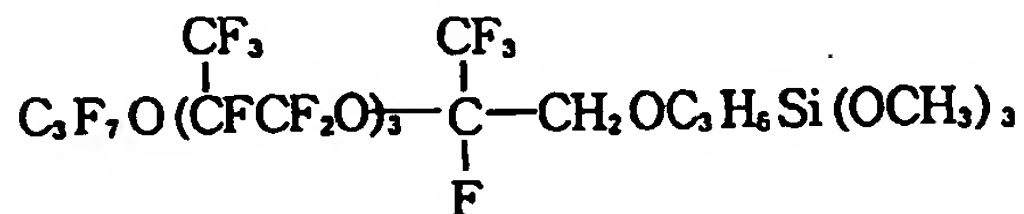
Thus, possible multigroup X's include $NH(CH_2)_2NH$, $OCONH$, $SO_2NR^3(CH_2)_2$ or 3 $CONH$.



Preferred among these are the following compounds.



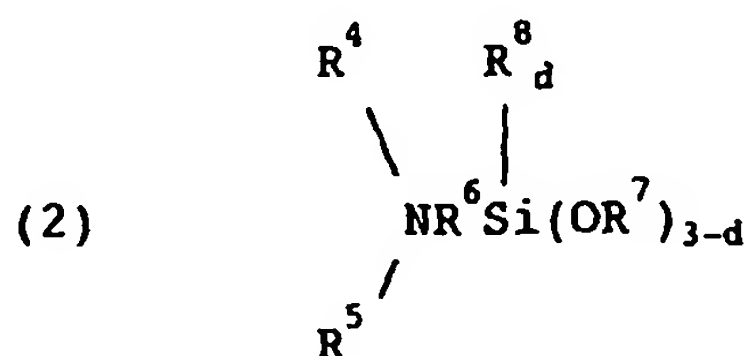
and



with the first-mentioned one being most preferred.

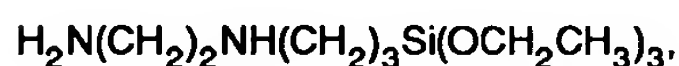
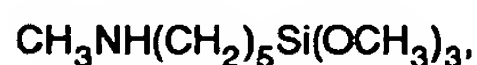
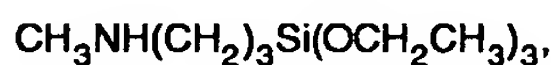
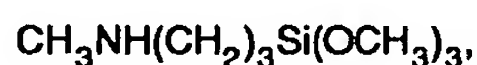
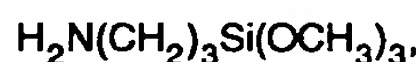
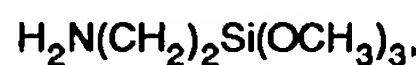
In the practice of the invention, not only silanes of formula (1), but also partial hydrolysates of the silanes 30 are useful as component (A) while a mixture of silane and partial hydrolysate is also acceptable. The partial hydrolysate should have at least one hydrolysate group left therein. A mixture of silanes and a mixture of partially hydrolysed silanes may also be used if desired.

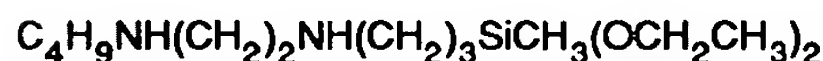
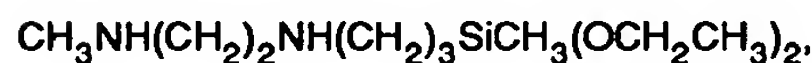
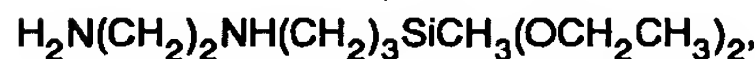
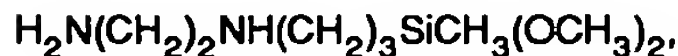
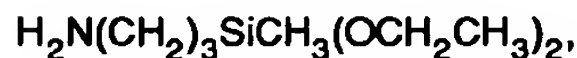
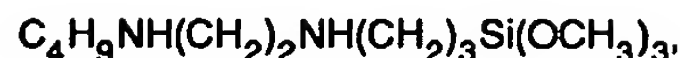
Component (B) is an amino group-containing alkoxysilane of the general formula (2).



In formula (2), each of R^4 and R^5 , which may be identical or different, is a hydrogen atom, alkyl group having 1 to 15 carbon atoms, preferably 1 to 4 carbon atoms or aminoalkyl group having 1 to 15 carbon atoms, preferably 1 to 6 carbon atoms. R^6 is a divalent hydrocarbon group having 1 to 18 carbon atoms, preferably 1 to 6 carbon atoms, such as alkylene, arylene, and alkylarylene groups. R^7 is an alkyl group having 1 to 4 carbon atoms. R^8 is an alkyl group having 1 to 4 carbon atoms. Letter d is equal to 0 or 1.

Illustrative, non-limiting, examples of the amino group-containing alkoxysilane are given below.





Preferred among these are N-(2-aminoethyl)-3-amino-propyltrimethoxysilane, N-(2-aminoethyl)-3-aminopropyl-methyldimethoxysilane, and 3-aminopropyltrimethoxysilane.

In the practice of the invention, not only silanes of formula (2), but also partial hydrolysates of the silanes are useful as component (B).

The water-soluble surface treating agent according to the first aspect contains a reaction product of components (A) and (B) as a main ingredient, which is dissolved in water. The reaction product is obtainable by effecting co-hydrolysis and condensation of components (A) and (B) in the presence of organic or inorganic acids. It is preferred from the stability point of view to produce the reaction product by first effecting partial hydrolysis of component (A) in the presence of an organic or inorganic acid and then reacting the partially hydrolysed component (A) with component (B).

Examples of the organic or inorganic acid used in hydrolysis of component (A) include hydrochloric acid, sulfuric

acid, methanesulfonic acid, formic acid, acetic acid, propionic acid, citric acid, oxalic acid, and maleic acid alone or in admixture, with acetic acid and propionic acid being preferred. The acid is preferably used in an amount of about 5 to 400 parts by weight, more preferably about 15 to 350 parts by weight per 100 parts by weight of component (A). With less than 5 parts of the acid, the progress of hydrolysis would be retarded and the agent in aqueous solution form would be less stable. Most preferably the acid catalyst is added in such an amount that when the reaction product is dissolved in water, the resulting aqueous system may be adjusted at pH 7.0 to 3.0.

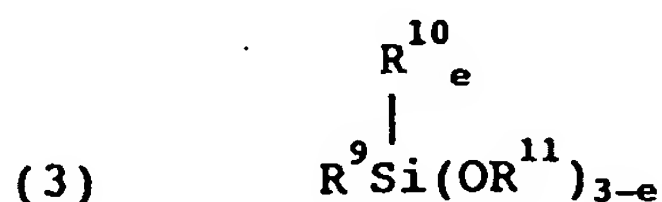
Upon hydrolysis, the reactant is preferably diluted with a solvent. The solvents used herein are preferably alcohol solvents including methanol, ethanol, 1-propanol, 2-propanol, 1-butanol, 2-butanol, and 3-butanol, with the 3-butanol being most preferred. The solvent is preferably used in an amount of about 100 to 500 parts by weight, more preferably about 200 to 400 parts by weight per 100 parts by weight of component (A). Less than 100 parts of the solvent would allow condensation to take place whereas more than 500 parts of the solvent would undesirably retard hydrolysis.

For hydrolysis, water is preferably added to component (A) in an amount of about 1.0 to 3.0 mol, more preferably 1.2 to 2.5 mol per mol of component (A). Less than 1.0 mol of water would leave much alkoxy groups whereas more than 3.0 mol of water would promote condensation. Preferred reaction conditions include a reaction temperature of 10 to 100°C, preferably 60 to 90°C and a reaction time of about 1 to 3 hours.

The thus hydrolysed component (A) is then successively reacted with component (B). The molar ratio of components (B) and (A) is preferably from 0.5:1.0 to 20.0:1.0. With a molar ratio of (B)/(A) of less than 0.5/1, water solubility would be low. With a molar ratio of (B)/(A) of more than 20.0/1, water repellency would be low. As to conditions for the reaction of component (B), a reaction temperature of 60 to 100°C and a reaction time of about 1 to 3 hours are preferred.

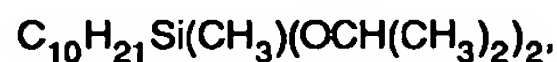
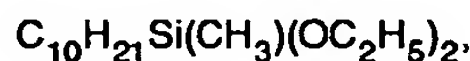
The water-soluble surface treating agent according to the second aspect contains a reaction product of the above-mentioned components (A) and (B) and the following component (C) as a main ingredient, which is dissolved in water.

Component (C) is an alkyl group-containing alkoxy silane of the general formula (3).



In formula (3), R^9 is a monovalent hydrocarbon group having 1 to 10 carbon atoms, R^{10} is an alkyl group having 1 to 4 carbon atoms, R^{11} is an alkyl group having 1 to 4 carbon atoms, and letter e is equal to 0 or 1. Examples of the monovalent hydrocarbon group include alkyl, alkenyl, aryl, and aralkyl groups and halogen substituted ones thereof, with the alkyl groups being preferred.

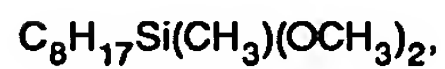
Illustrative, non-limiting, examples of the alkyl group-containing alkoxy silane are given below.



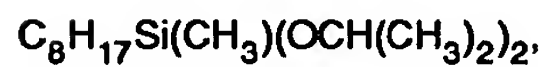
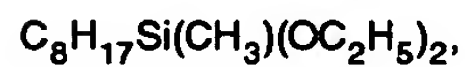
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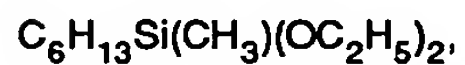
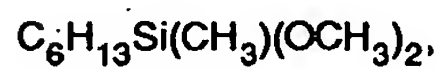
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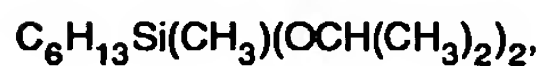
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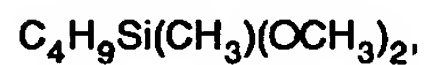
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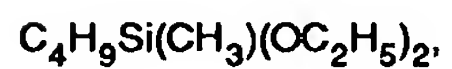
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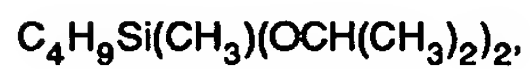
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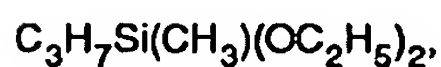
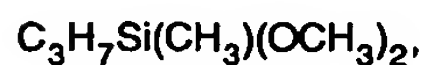
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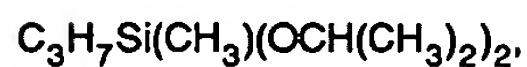
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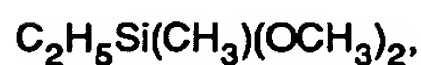
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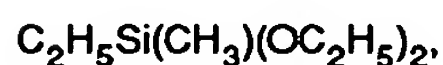
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Preferred among these are $\text{C}_{10}\text{H}_{21}\text{Si}(\text{OCH}_3)_3$, $\text{C}_{10}\text{H}_{21}\text{Si}(\text{CH}_3)(\text{OCH}_3)_2$, $(\text{CH}_3)_2\text{Si}(\text{OCH}_3)_2$, and $(\text{CH}_3)_2\text{Si}(\text{OC}_2\text{H}_5)_2$.

50 In the practice of the invention, not only silanes of formula (3) but also partial hydrolysates of the silanes are useful as component (C).

The reaction product of components (A), (B) and (C) is obtainable by effecting co-hydrolysis and condensation of components (A), (B) and (C) in the presence of organic or inorganic acids. It is preferred from the stability point of view to produce the reaction product by first effecting partial hydrolysis of components (A) and (C) in the presence of an organic or inorganic acid and then reacting the partially hydrolysed components (A) and (C) with component (B).

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Examples of the organic or inorganic acid used in hydrolysis of components (A) and (C) include hydrochloric acid, sulfuric acid, methanesulfonic acid, formic acid, acetic acid, propionic acid, citric acid, oxalic acid, and maleic acid alone or in admixture, with acetic acid and propionic acid being preferred. The acid is preferably used in an amount of

about 30 to 400 parts by weight, more preferably about 40 to 350 parts by weight per 100 parts by weight of components (A) and (C) combined. With less than 30 parts of the acid, the progress of hydrolysis would be retarded and the agent in aqueous solution form would be less stable. Most preferably the acid catalyst is added in such an amount that when the reaction product is dissolved in water, the resulting aqueous system may be adjusted at pH 7.0 to 3.0.

Upon hydrolysis, the reactants are preferably diluted with a solvent. The solvents used herein are preferably alcohol solvents including methanol, ethanol, 1-propanol, 2-propanol, 1-butanol, 2-butanol, 3-butanol, and 2-methyl-2-butanol, with the 3-butanol being most preferred. The solvent is preferably used in an amount of about 100 to 500 parts by weight, more preferably about 200 to 400 parts by weight per 100 parts by weight of components (A) and (C) combined. Less than 100 parts of the solvent would allow condensation to take place whereas more than 500 parts of the solvent would undesirably retard hydrolysis.

For hydrolysis, water is preferably added to components (A) and (C) in an amount of about 1 to 3 mol, more preferably 1.2 to 2.5 mol per mol of components (A) and (C) combined. Less than 1 mol of water would leave much alkoxy groups whereas more than 3 mol of water would promote condensation. Preferred reaction conditions include a reaction temperature of 10 to 100°C, preferably 60 to 90°C and a reaction time of about 1 to 3 hours.

The molar ratio of components (C) and (A) is preferably from 0.05:1 to 0.5:1. With a molar ratio of (C)/(A) of less than 0.05/1, durability would be low. With a molar ratio of (C)/(A) of more than 0.5/1, water solubility and/or oil repellency would be low.

The thus hydrolysed product of components (A) and (C) is then successively reacted with component (B). The molar ratio of component (B) to components (A) and (C) combined is preferably from 0.5:1 to 20:1. With a molar ratio of (B)/(A + C) of less than 0.5/1, water solubility would be low. With a molar ratio of (B)/(A + C) of more than 20/1, water repellency would be low. As to conditions for the reaction of component (B), a reaction temperature of 60 to 100°C and a reaction time of about 1 to 3 hours are preferred.

The water-soluble surface treating agent may be used by diluting with water such that e.g. the concentration of water may be 99.9 to 90% by weight, more preferably 99 to 97% by weight. With a water concentration of more than 99.9% by weight, it may be difficult to take advantage of the reaction product and an excessively large amount of the dilution must be applied. A water concentration of less than 90% by weight may sometimes lead to shelf instability.

To the water-soluble surface treating agent of the invention, surfactants and well-known additives such as alcohols may be added for improving substrate wettability and aqueous solution stability insofar as the objects of the invention are not impaired. Metal base curing catalysts such as Al, Sn and Zn may also be added if desired.

The water-soluble surface treating agents disclosed herein may be applied to substrates of glass, inorganic materials, ceramics, metals or plastics for imparting thereto water repellent, oil repellent, moisture-proof, stain-proof, anti-icing, lubricant, mold release, weather resistant, and durable properties. The substrates can be treated with the agent by well-known techniques such as coating, dipping, and spraying. The agent will find use as water repellent agents, oil repellent agents, moisture-proof agents, anti-icing agents, anti-staining agents, lubricants, and mold release agents. More specifically, the agent is useful for the purposes of moisture-proof treatment of electronic parts, anti-staining surface treatment of optical lenses, moisture-proof, anti-staining, and lubricating surface treatment of optical and magnetic recording media, anti-staining surface treatment of liquid crystal displays and CRT displays, anti-staining and moisture-proof treatment of transparent plastic parts such as optical disc pickups, water-repellent and anti-icing surface treatment of glass and plastic glazing in automobiles, trains, aircraft, and helicopters, water-repellent and anti-staining surface treatment of building glazing, water-repellent and anti-icing surface treatment of radar antennas, TV antennas, and roofing, mold release treatment of molds for plastic molding, anti-staining treatment of electronic parts and precision equipment against lubricating oil, and water-repellent and lubricating wet treatment of oxides such as silica and titanium oxide.

EXAMPLE

Examples of the invention are given below by way of illustration and not by way of limitation.

Synthesis Example 1

A 1.0-liter four-necked flask equipped with a stirrer, condenser, thermometer, and dropping funnel was charged with 100 grams (0.176 mol) of $C_8F_{17}(CH_2)_2Si(OCH_3)_3$, 340 grams of 3-butanol, 26.3 grams (0.438 mol) of acetic acid, and 4.75 grams (0.264 mol) of water. With stirring, the flask was heated until 3-butanol refluxed. Reaction was continued for 2 hours in this condition. To the flask, 39.1 grams (0.176 mol) of $H_2N(CH_2)_2HN(CH_2)_3Si(OCH_3)_3$ was added dropwise. Reaction was continued for a further 1 hour under reflux of 3-butanol, obtaining a pale yellow clear liquid.

Synthesis Example 2

The procedure of Synthesis Example 1 was repeated except that 34.8 grams (0.58 mol) of acetic acid and 78.1 grams (0.352 mol) of $\text{H}_2\text{N}(\text{CH}_2)_2\text{HN}(\text{CH}_2)_3\text{Si}(\text{OCH}_3)_3$ were used. There was obtained a pale yellow clear liquid.

Synthesis Example 3

The procedure of Synthesis Example 1 was repeated except that methanol was used instead of the 3-butanol. Thereafter, the reaction solution was heated at 110°C to distill off the methanol, obtaining a yellow white viscous product.

Synthesis Example 4

The procedure of Synthesis Example 2 was repeated except that methanol was used instead of the 3-butanol. Thereafter, the reaction solution was heated at 110°C to distill off the methanol, obtaining a yellow white viscous product.

Synthesis Example 5

The procedure of Synthesis Example 1 was repeated except that 36.3 grams (0.176 mol) of $\text{H}_2\text{N}(\text{CH}_2)_2\text{HN}(\text{CH}_2)_3\text{SiCH}_3(\text{OCH}_3)_2$ was used instead of $\text{H}_2\text{N}(\text{CH}_2)_2\text{HN}(\text{CH}_2)_3\text{Si}(\text{OCH}_3)_3$. There was obtained a pale yellow clear liquid.

Synthesis Example 6

The procedure of Synthesis Example 1 was repeated except that 15.8 grams (0.264 mol) of acetic acid was used and 31.5 grams (0.176 mol) of $\text{H}_2\text{N}(\text{CH}_2)_3\text{Si}(\text{OCH}_3)_3$ was used instead of $\text{H}_2\text{N}(\text{CH}_2)_2\text{HN}(\text{CH}_2)_3\text{Si}(\text{OCH}_3)_3$. There was obtained a clear liquid.

Synthesis Example 7

The procedure of Synthesis Example 1 was repeated except that 107.5 grams (0.176 mol) of $\text{C}_8\text{F}_{17}\text{CONH}(\text{CH}_2)_2\text{Si}(\text{OCH}_3)_3$ was used instead of $\text{C}_8\text{F}_{17}(\text{CH}_2)_2\text{Si}(\text{OCH}_3)_3$. There was obtained a pale yellow clear liquid.

Synthesis Example 8

A 1.0-liter four-necked flask equipped with a stirrer, condenser, thermometer, and dropping funnel was charged with 129.2 grams (0.33 mol) of $\text{C}_{18}\text{H}_{37}\text{SiCl}_3$ and 200 grams of methylene chloride. With stirring, 89 grams (1.0 mol) of 2-dimethylaminoethanol diluted with 100 grams of methylene chloride was added dropwise to the flask from the dropping funnel. At the end of addition, 670 grams of 3-butanol was added to the contents, which were further stirred. The reaction solution was heated at 80°C to distill off the methylene chloride. After cooling, 60 grams (1.0 mol) of acetic acid was added to the contents, which were stirred. Upon filtration, there was obtained a pale yellow clear liquid.

Synthesis Example 9

A 1.0-liter four-necked flask equipped with a stirrer, condenser, thermometer, and dropping funnel was charged with 100 grams (0.172 mol) of $\text{C}_8\text{F}_{17}\text{C}_2\text{H}_4\text{SiCl}_3$ and 152 grams of hexane. With stirring, 46 grams (0.516 mol) of 2-dimethylaminoethanol diluted with 23 grams of hexane was added dropwise to the flask from the dropping funnel. At the end of addition, the contents were stirred for 1 hour and 358 grams of 3-butanol was added to the contents, which were further stirred. The reaction solution was heated at 80°C to distill off the hexane. After cooling, 32 grams (0.53 mol) of acetic acid was added to the contents, which were stirred. Upon filtration, there was obtained a pale yellow clear liquid.

Synthesis Example 10

A 1.0-liter four-necked flask equipped with a stirrer, condenser, thermometer, and dropping funnel was charged with 15 grams (0.026 mol) of $\text{C}_8\text{F}_{17}(\text{CH}_2)_2\text{Si}(\text{OCH}_3)_3$, 735 grams of 2-propanol, and 0.48 grams of 0.01N hydrochloric acid. With stirring, the flask was heated until 2-propanol refluxed. Reaction was continued for 2 hours in this condition, obtaining a clear liquid.

Example 1

A surface treating agent aqueous solution was prepared by diluting the reaction solution obtained in Synthesis Example 1 with water so that the concentration of its active component was 2% by weight. The solution was allowed to stand at room temperature for one month whereupon no change was observed.

Glass plates of 70 mm x 150 mm x 3 mm thick were dipped for 5 minutes in the solution both immediately after preparation and after aging at room temperature for one week. The treated glass plates were washed with water and heated at 100°C for 15 minutes. These samples were examined for water repellency by measuring a contact angle with water. The results are shown in Table 1.

(a) Contact angle

A contact angle of a sample with water was measured. Measurement was done at five different points on the substrate surface. With maximum and minimum measurements cut off, an average of the remaining measurements was calculated.

(b) Boiling test

A sample was dipped in boiling water for 1 hour before its contact angle with water was measured by the same procedure as above.

Example 2

A surface treating agent aqueous solution was prepared by diluting the reaction solution obtained in Synthesis Example 2 with water so that the concentration of its active component was 2% by weight. The solution was allowed to stand at room temperature for one month whereupon no change was observed.

Glass plates of 70 mm x 150 mm x 3 mm thick were dipped for 5 minutes in the solution both immediately after preparation and after aging at room temperature for one week. The treated glass plates were washed with water and heated at 100°C for 15 minutes. The test results of these samples are shown in Table 1.

Example 3

A surface treating agent aqueous solution was prepared by diluting 2 parts by weight of the reaction product obtained in Synthesis Example 3 with 98 parts by weight of water. The solution was allowed to stand at room temperature for one month whereupon no change was observed.

Glass plates of 70 mm x 150 mm x 3 mm thick were dipped for 5 minutes in the solution both immediately after preparation and after aging at room temperature for one week. The treated glass plates were washed with water and heated at 100°C for 15 minutes. The test results of these samples are shown in Table 1.

Example 4

A surface treating agent aqueous solution was prepared by diluting 2 parts by weight of the reaction product obtained in Synthesis Example 4 with 98 parts by weight of water. The solution was allowed to stand at room temperature for one month whereupon no change was observed.

Glass plates of 70 mm x 150 mm x 3 mm thick were dipped for 5 minutes in the solution both immediately after preparation and after aging at room temperature for one week. The treated glass plates were washed with water and heated at 100°C for 15 minutes. The test results of these samples are shown in Table 1.

Example 5

A surface treating agent aqueous solution was prepared by diluting the reaction solution obtained in Synthesis Example 5 with water so that the concentration of its active component was 2% by weight. The solution was allowed to stand at room temperature for one month whereupon no change was observed.

Glass plates of 70 mm x 150 mm x 3 mm thick were dipped for 5 minutes in the solution both immediately after preparation and after aging at room temperature for one week. The treated glass plates were washed with water and heated at 100°C for 15 minutes. The test results of these samples are shown in Table 1.

Example 6

A surface treating agent aqueous solution was prepared by diluting the reaction solution obtained in Synthesis Example 6 with water so that the concentration of its active component was 2% by weight. The solution was allowed to stand at room temperature for one month whereupon no change was observed.

Glass plates of 70 mm x 150 mm x 3 mm thick were dipped for 5 minutes in the solution both immediately after preparation and after aging at room temperature for one week. The treated glass plates were washed with water and heated at 100°C for 15 minutes. The test results of these samples are shown in Table 1.

Example 7

A surface treating agent aqueous solution was prepared by diluting the reaction solution obtained in Synthesis Example 7 with water so that the concentration of its active component was 2% by weight. The solution was allowed to stand at room temperature for one month whereupon no change was observed.

Glass plates of 70 mm x 150 mm x 3 mm thick were dipped for 5 minutes in the solution both immediately after preparation and after aging at room temperature for one week. The treated glass plates were washed with water and heated at 100°C for 15 minutes. The test results of these samples are shown in Table 1.

Comparative Example 1

A surface treating agent aqueous solution was prepared by diluting the reaction solution obtained in Synthesis Example 8 with water so that the concentration of its active component was 2% by weight. The solution became white turbid after it was allowed to stand at room temperature for one day. A glass plate of 70 mm x 150 mm x 3 mm thick was dipped in the solution for 5 minutes, washed with water, and heated at 100°C for 15 minutes. The test results of this sample are shown in Table 1.

Comparative Example 2

A surface treating agent aqueous solution was prepared by diluting the reaction solution obtained in Synthesis Example 9 with water so that the concentration of its active component was 2% by weight. The solution was white turbid immediately after preparation. A glass plate of 70 mm x 150 mm x 3 mm thick was dipped in the solution for 5 minutes, washed with water, and heated at 100°C for 15 minutes. The test results of this sample are shown in Table 1.

Comparative Example 3

A surface treating agent aqueous solution was prepared by diluting the reaction solution obtained in Synthesis Example 10 with water so that the concentration of its active component was 2% by weight. A glass plate of 70 mm x 150 mm x 3 mm thick was dipped in the solution for 5 minutes, washed with water, and heated at 100°C for 15 minutes. The test results of this sample are shown in Table 1.

Table 1

	Contact angle (°)		Contact angle (°) after boiling test	
	Fresh	7 days	Fresh	7 days
Example 1	108	107	103	102
Example 2	107	107	102	102
Example 3	108	106	102	100
Example 4	108	106	101	100
Example 5	108	105	100	101
Example 6	108	107	102	102
Example 7	107	107	102	100
CE 1	80	inapplicable	61	inapplicable
CE 2	93	85	88	79

Table 1 (continued)

	Contact angle (°)		Contact angle (°) after boiling test	
	Fresh	7 days	Fresh	7 days
CE 3	102	100	95	93

Synthesis Example 11

A 0.5-liter four-necked flask equipped with a stirrer, condenser, thermometer, and dropping funnel was charged with 48.8 grams (0.086 mol) of $C_8F_{17}(CH_2)_2Si(OCH_3)_3$, 1.2 grams (0.009 mol) of $(CH_3)_2Si(OCH_3)_2$, 169 grams of 3-butanol, 14.2 grams (0.237 mol) of acetic acid, and 2.6 grams (0.142 mol) of water. With stirring, the flask was heated until 3-butanol refluxed. Reaction was continued for 2 hours in this condition. To the flask, 21.0 grams (0.095 mol) of $H_2N(CH_2)_2HN(CH_2)_3Si(OCH_3)_3$ was added dropwise. Reaction was continued for a further 1 hour under reflux of 3-butanol, obtaining a pale yellow clear liquid.

Synthesis Example 12

A 0.5-liter four-necked flask equipped with a stirrer, condenser, thermometer, and dropping funnel was charged with 48.0 grams (0.085 mol) of $C_8F_{17}(CH_2)_2Si(OCH_3)_3$, 2.0 grams (0.017 mol) of $(CH_3)_2Si(OCH_3)_2$, 169 grams of 3-butanol, 15.1 grams (0.253 mol) of acetic acid, and 2.7 grams (0.152 mol) of water. With stirring, the flask was heated until 3-butanol refluxed. Reaction was continued for 2 hours in this condition. To the flask, 22.5 grams (0.101 mol) of $H_2N(CH_2)_2HN(CH_2)_3Si(OCH_3)_3$ was added dropwise. Reaction was continued for a further 1 hour under reflux of 3-butanol, obtaining a pale yellow clear liquid.

Synthesis Example 13

A 0.5-liter four-necked flask equipped with a stirrer, condenser, thermometer, and dropping funnel was charged with 48.8 grams (0.086 mol) of $C_8F_{17}(CH_2)_2Si(OCH_3)_3$, 1.2 grams (0.009 mol) of $(CH_3)_2Si(OCH_3)_2$, 169 grams of 3-butanol, 8.5 grams (0.142 mol) of acetic acid, and 2.6 grams (0.142 mol) of water. With stirring, the flask was heated until 3-butanol refluxed. Reaction was continued for 2 hours in this condition. To the flask, 16.9 grams (0.095 mol) of $H_2N(CH_2)_2HN(CH_2)_3Si(OCH_3)_3$ was added dropwise. Reaction was continued for a further 1 hour under reflux of 3-butanol, obtaining a clear liquid.

Synthesis Example 14

The procedure of Synthesis Example 11 was repeated except that 2.3 grams (0.009 mol) of $C_{10}H_{21}Si(OCH_3)_3$ was used instead of $(CH_3)_2Si(OCH_3)_2$. There was obtained a pale yellow clear liquid.

Synthesis Example 15

The procedure of Synthesis Example 11 was repeated except that 1.8 grams (0.009 mol) of $C_6H_{13}Si(OCH_3)_3$ was used instead of $(CH_3)_2Si(OCH_3)_2$. There was obtained a pale yellow clear liquid.

Synthesis Example 16

The procedure of Synthesis Example 11 was repeated except that 1.4 grams (0.009 mol) of $C_3H_7Si(OCH_3)_3$ was used instead of $(CH_3)_2Si(OCH_3)_2$. There was obtained a pale yellow clear liquid.

Synthesis Example 17

The procedure of Synthesis Example 11 was repeated except that 52.5 grams (0.086 mol) of $C_8F_{17}CONH(CH_2)_2Si(OCH_3)_3$ was used instead of $C_8F_{17}(CH_2)_2Si(OCH_3)_3$. There was obtained a pale yellow clear liquid.

Synthesis Example 18

The procedure of Synthesis Example 11 was repeated except that 8.6 grams (0.143 mol) of acetic acid was used and 17.0 grams (0.095 mol) of $H_2N(CH_2)_3Si(OCH_3)_3$ was used instead of $H_2N(CH_2)_2HN(CH_2)_3Si(OCH_3)_3$. There was

obtained a clear liquid.

Example 8

5 A surface treating agent aqueous solution was prepared by diluting the reaction solution obtained in Synthesis Example 11 with water so that the concentration of its active component was 2% by weight. The solution was allowed to stand at room temperature for one month whereupon no change was observed.

10 Glass plates of 70 mm x 150 mm x 3 mm thick were dipped for 5 minutes in the solution both immediately after preparation and after aging at room temperature for one week. The treated glass plates were air dried at 25°C for 24 hours and wiped with ethanol. These samples were examined for water repellency by measuring a contact angle with water. The results are shown in Table 2.

(a) Contact angle

15 A contact angle of a sample with water was measured. Measurement was done at five different points on the substrate surface. With maximum and minimum measurements cut off, an average of the remaining measurements was calculated.

(b) Boiling test

20 A sample was dipped in boiling water for 1 hour before its contact angle with water was measured by the same procedure as above.

(c) Wear test

25 Using a scratch abrasion tester (manufactured by KNT K.K.), sample was subject to a fabric abrasion test under a load of 1 kg/cm² for 3,000 cycles. Its contact angle with water was then measured by the same procedure as above.

Example 9

30 A surface treating agent aqueous solution was prepared by diluting the reaction solution obtained in Synthesis Example 12 with water so that the concentration of its active component was 2% by weight. The solution was allowed to stand at room temperature for one month, with no change observed.

35 Glass plates of 70 mm x 150 mm x 3 mm thick were dipped for 5 minutes in the solution both immediately after preparation and after aging at room temperature for one week. The treated glass plates were air dried at 25°C for 24 hours and wiped with ethanol. The test results of these samples are shown in Table 2.

Example 10

40 A surface treating agent aqueous solution was prepared by diluting the reaction solution obtained in Synthesis Example 13 with water so that the concentration of its active component was 2% by weight. The solution was allowed to stand at room temperature for one month, with no change observed.

45 Glass plates of 70 mm x 150 mm x 3 mm thick were dipped for 5 minutes in the solution both immediately after preparation and after aging at room temperature for one week. The treated glass plates were air dried at 25°C for 24 hours and wiped with ethanol. The test results of these samples are shown in Table 2.

Example 11

50 A surface treating agent aqueous solution was prepared by diluting the reaction solution obtained in Synthesis Example 14 with water so that the concentration of its active component was 2% by weight. The solution was allowed to stand at room temperature for one month, with no change observed.

Glass plates of 70 mm x 150 mm x 3 mm thick were dipped for 5 minutes in the solution both immediately after preparation and after aging at room temperature for one week. The treated glass plates were air dried at 25°C for 24 hours and wiped with ethanol. The test results of these samples are shown in Table 2.

55

Example 12

A surface treating agent aqueous solution was prepared by diluting the reaction solution obtained in Synthesis

Example 15 with water so that the concentration of its active component was 2% by weight. The solution was allowed to stand at room temperature for one month, with no change observed.

Glass plates of 70 mm x 150 mm x 3 mm thick were dipped for 5 minutes in the solution both immediately after preparation and after aging at room temperature for one week. The treated glass plates were air dried at 25°C for 24 hours and wiped with ethanol. The test results of these samples are shown in Table 2.

Example 13

A surface treating agent aqueous solution was prepared by diluting the reaction solution obtained in Synthesis Example 16 with water so that the concentration of its active component was 2% by weight. The solution was allowed to stand at room temperature for one month, with no change observed.

Glass plates of 70 mm x 150 mm x 3 mm thick were dipped for 5 minutes in the solution both immediately after preparation and after aging at room temperature for one week. The treated glass plates were air dried at 25°C for 24 hours and wiped with ethanol. The test results of these samples are shown in Table 2.

Example 14

A surface treating agent aqueous solution was prepared by diluting the reaction solution obtained in Synthesis Example 17 with water so that the concentration of its active component was 2% by weight. The solution was allowed to stand at room temperature for one month, with no change observed.

Glass plates of 70 mm x 150 mm x 3 mm thick were dipped for 5 minutes in the solution both immediately after preparation and after aging at room temperature for one week. The treated glass plates were air dried at 25°C for 24 hours and wiped with ethanol. The test results of these samples are shown in Table 2.

Example 15

A surface treating agent aqueous solution was prepared by diluting the reaction solution obtained in Synthesis Example 18 with water so that the concentration of its active component was 2% by weight. The solution was allowed to stand at room temperature for one month, with no change observed.

Glass plates of 70 mm x 150 mm x 3 mm thick were dipped for 5 minutes in the solution both immediately after preparation and after aging at room temperature for one week. The treated glass plates were air dried at 25°C for 24 hours and wiped with ethanol. The test results of these samples are shown in Table 2.

Comparative Example 4

A surface treating agent aqueous solution was prepared by diluting the reaction solution obtained in Synthesis Example 8 with water so that the concentration of its active component was 2% by weight. The solution became white turbid after it was allowed to stand at room temperature for 1 day. A glass plate of 70 mm x 150 mm x 3 mm thick was dipped in the solution for 5 minutes, air dried at 25°C for 24 hours and wiped with ethanol. The test results of this sample are shown in Table 2.

Comparative Example 5

A surface treating agent aqueous solution was prepared by diluting the reaction solution obtained in Synthesis Example 9 with water so that the concentration of its active component was 2% by weight. The solution was white turbid immediately after preparation. A glass plate of 70 mm x 150 mm x 3 mm thick was dipped in the solution for 5 minutes, air dried at 25°C for 24 hours and wiped with ethanol. The test results of this sample are shown in Table 2.

Comparative Example 6

A surface treating agent aqueous solution was prepared by diluting the reaction solution obtained in Synthesis Example 10 with water so that the concentration of its active component was 2% by weight. A glass plate of 70 mm x 150 mm x 3 mm thick was dipped in the solution for 5 minutes, air dried at 25°C for 24 hours and wiped with ethanol. The test results of this sample are shown in Table 2.

Table 2

	Contact angle (°)		Contact angle (°) after boiling test		Contact angle (°) after abrasion test	
	Fresh	7 days	Fresh	7 days	Fresh	7 days
Example 8	105	105	98	97	100	99
Example 9	101	102	97	98	98	99
Example 10	104	105	97	99	96	96
Example 11	102	103	93	92	98	97
Example 12	101	102	91	89	90	90
Example 13	100	101	88	86	89	90
Example 14	103	101	96	94	97	97
Example 15	105	105	98	96	100	98
CE 4	80	<20	43	<20	40	<20
CE 5	94	82	62	58	48	41
CE 6	102	100	61	59	45	43

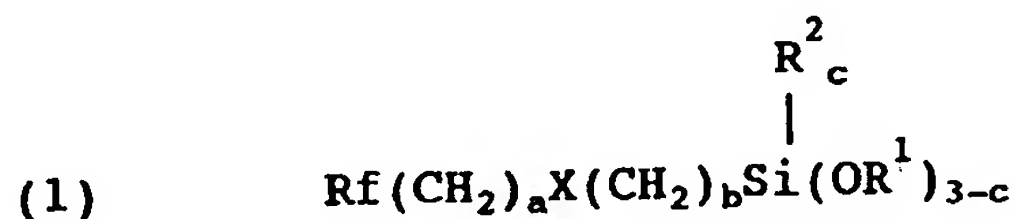
There have been described water-soluble surface treating agents which have good water solubility and shelf stability since water solubility is imparted to a fluoroalkyl group-containing silane compound itself. An aqueous solution of the agent is applied to glass and other substrates to impart water repellency and other good surface properties to the substrates, and these good properties were long-lasting.

Japanese Patent Application Nos. 119304/1995 and 329860/1995 are incorporated herein by reference.

Although some preferred embodiments have been described, many modifications and variations may be made thereto in the light of the above teachings. It is therefore to be understood that within the scope of the general teachings herein, the invention may be practised otherwise than as specifically described in Examples.

Claims

1. A water-soluble surface treating agent comprising as an active ingredient a reaction product of (A) fluoroalkyl group-containing alkoxy silane of the general formula (1):



wherein Rf is $\text{C}_n\text{F}_{2n+1}$ or a polyfluoroalkyl group represented by



wherein n is an integer of 1 to 20 and m is an integer of at least 1, which may have at least one ether bond,

X is at least one linkage group selected from the class consisting of $-\text{CH}_2-$, $-\text{CH}_2\text{O}-$, $-\text{NR}^3-$, $-\text{CO}_2-$, $-\text{CONR}^3-$, $-\text{S}-$, $-\text{SO}_3-$, and $-\text{SO}_2\text{NR}^3-$ wherein R^3 are hydrogen atom or alkyl groups of 1 to 8 carbon atoms,

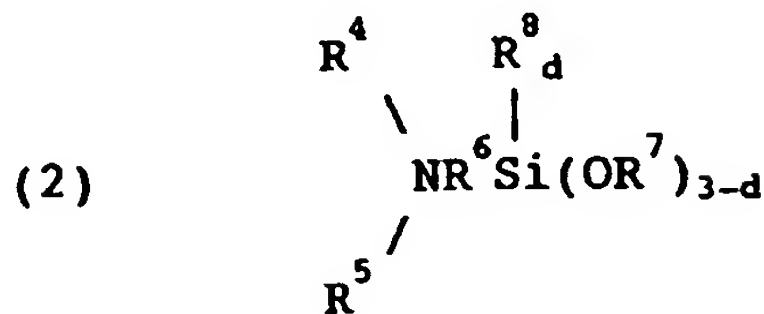
R^1 are alkyl groups having 1 to 4 carbon atoms,

R^2 are alkyl groups having 1 to 4 carbon atoms,

a is an integer of 0 to 3, b is an integer of 1 to 3, and c is equal to 0 or 1, and/or partial hydrolysate

thereof and

(B) amino group-containing alkoxy silane of the general formula (2):



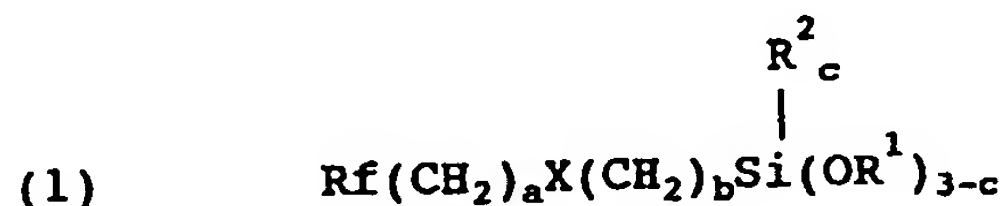
wherein R^4 and R^5 are independently selected from the class consisting of hydrogen atom, alkyl groups having 1 to 15 carbon atoms, and aminoalkyl groups having 1 to 15 carbon atoms, R^6 is a divalent hydrocarbon group having 1 to 18 carbon atoms,

R^7 are alkyl groups having 1 to 4 carbon atoms,

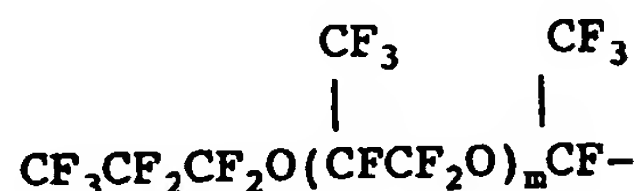
R^8 are alkyl groups having 1 to 4 carbon atoms, and

d is equal to 0 or 1, and/or a partial hydrolysate thereof.

2. An agent of claim 1 wherein the reaction product is obtained by reacting components (B) and (A) in a molar ratio of from 0.5/1.0 to 20.0/1.0.
3. An agent of claim 1 comprising 0.1 to 10% by weight of the reaction product and 99.9 to 90% by weight of water.
4. A water-soluble surface treating agent comprising as a main ingredient a reaction product of (A) fluoroalkyl group-containing alkoxy silane of the general formula (1):



wherein Rf is C_nF_{2n+1} or a polyfluoroalkyl group represented by



wherein n is an integer of 1 to 20 and m is an integer of at least 1, which may have at least one ether bond,

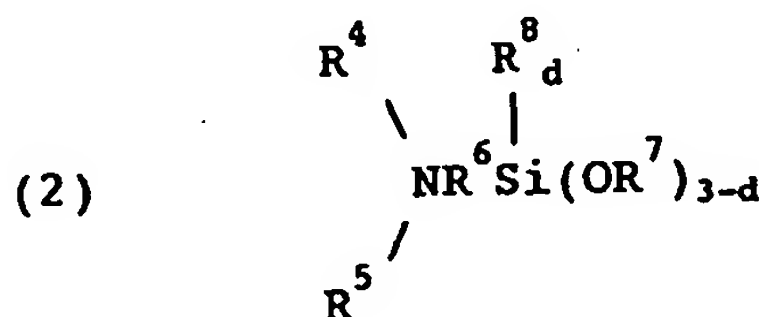
X is at least one linkage group selected from the class consisting of $-CH_2-$, $-CH_2O-$, $-NR^3-$, $-CO_2-$, $-CONR^3-$, $-S-$, $-SO_3-$, and $-SO_2NR^3-$, wherein R^3 are hydrogen atom or alkyl groups of 1 to 8 carbon atoms

R^1 are alkyl groups having 1 to 4 carbon atoms,

R^2 are alkyl groups having 1 to 4 carbon atoms,

a is an integer of 0 to 3, b is an integer of 1 to 3, and c is equal to 0 or 1, and/or a partial hydrolysate thereof,

(B) amino group-containing alkoxy silane of the general formula (2):



wherein R^4 and R^5 are independently selected from the class consisting of hydrogen atom, alkyl groups having 1 to 15 carbon atoms, and aminoalkyl groups having 1 to 15 carbon atoms,

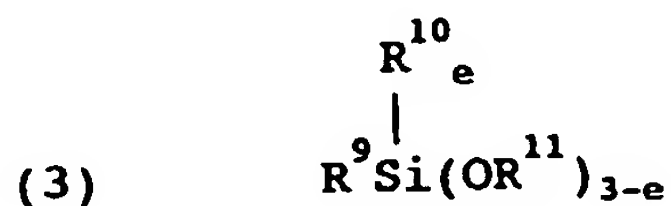
R^6 is a divalent hydrocarbon group having 1 to 18 carbon atoms,

R^7 are alkyl groups having 1 to 4 carbon atoms,

R^8 are alkyl groups having 1 to 4 carbon atoms, and

d is equal to 0 or 1, and/or a partial hydrolysate thereof, and

(C) alkyl group-containing alkoxysilane of the general formula (3):



wherein R^9 is a monovalent hydrocarbon group having 1 to 10 carbon atoms,

R^{10} is an alkyl group having 1 to 4 carbon atoms,

R^{11} is an alkyl group having 1 to 4 carbon atoms, and

e is equal to 0 or 1, and/or a partial hydrolysate thereof.

5. An agent of claim 4 wherein the reaction product is obtained by reacting components (A) and (C) in a molar ratio (C)/(A) of from 0.05/1 to 0.5/1 and further reacting them with component (B) in a molar ratio (B)/(A + C) of from 0.5/1 to 20/1.
6. An agent of claim 4 comprising 0.1 to 10% by weight of the reaction product and 99.9 to 90% by weight of water.
7. A method of making a surface treating agent according to claim 1 or 2, by reacting said components (A) and (B), or a surface treating agent according to claim 4 or 5, by reacting said components (A), (B) and (C).
8. Use of an agent according to any one of claims 1 to 6 to treat a surface of a substrate.



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 96 30 2722

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A,D	US-A-2 814 572 (FRYE) * claims 1-9; examples 12-24 *	1-8	C09K3/18 C03C17/30
A	--- DATABASE WPI Week 8404 Derwent Publications Ltd., London, GB; AN 84-020682 XP002008717 & JP-A-58 211 701 (ASAHI GLASS) * abstract *	1-8	
A	--- EP-A-0 548 775 (CENTRAL GLASS COMPANY) * abstract; claims 1-8; examples 1-5 *	1-8	
A,P	--- DE-A-44 18 308 (BAYER AG) * abstract; claims 1-5 *	1-8	
A	--- US-A-5 274 159 (PELLERITE) * abstract; claims 1-6; examples 1-5 *	1-8	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			C09K C03C
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 18 July 1996	Examiner Nicolas, H
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p>			

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